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Improving the Top mass measurement in L+J by using the 3 best combinations

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Abstract

The BLUE method is applicable to improve the precision in the Top mass measurement, whenever the mass can be reconstructed in a number of different ways for each candidate event. We apply this method to a pretag pseudo-data sample in the lepton + jet channel using the classic Template Method. Currently, this method uses only the mass value returned by the most likely jet-to-parton association (out of 24). In this note we exploit the mass information returned by the three best combinations. We find that the statistical error is improved by about 10%.

Contents

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1 Introduction

Getting a mass value from a Top event in the lepton + jet channel implies to chose among 24 possible reconstructions of the event. Candidates are selected to have at least 4 jets over the $E_t > 15\ GeV$ threshold, one lepton over 20 GeV in p_T and MET$> 20\ GeV$.

In general, the possible permutations of 4 jets are $4! = 24$, but since if we exchange the two light jets attributed to the W the mass value does not change, the combinations returning different masses are only 12. On the other hand, the conservation equation determine the squared longitudinal neutrino momentum, and the ambiguity of the 2 possible values of this component of the neutrino momentum increases again to 24 the number of possible reconstructions. Often this ambiguity does not impact appreciably the reconstructed Top mass, and effectively amounts to doubling the same solution.

The event fitting procedure used minimizes a χ^2 quantity depending on a number of kinematic variables. The returned mass is, for each combination of each event, the m_{reco} for which the χ^2 value, as reported in equation 1 is minimum.

$$\begin{aligned}\chi^2 \quad = \quad & \textstyle\sum_{i=l,\ 4jets} \frac{(p_T^{i,fit}-p_T^{i,data})^2}{\sigma_i^2} \quad + \quad \textstyle\sum_{j=x,y} \frac{(p_j^{UE,fit}-p_j^{UE,data})^2}{\sigma_j^2} \\ + \quad & \frac{(M_{jj}-M_W)^2}{\Gamma_W^2} + \frac{(M_{l\nu}-M_W)^2}{\Gamma_W^2} \quad + \quad \frac{(M_{bjj}-M_t)^2}{\Gamma_t^2} + \frac{(M_{bl\nu}-M_t)^2}{\Gamma_t^2}\end{aligned} \tag{1}$$

The standard procedure, when using the Template Method, is to order the 24 combinations by increasing χ^2s and to choose the reconstruction associated with the lowest χ^2 value. The M_{top} returned by this combination is the reconstructed Top mass.

With MC simulations, we can count how many times we expect this choice to be the correct one. To do that, we first assume that we are able to correctly match the jets to the partons, so that the correct 4 leading jets are selected. Under this assumption which is correct about 54% of times, although the combination associated with the lowest χ^2 has the best chance to be the correct one, this happens only in about 50% of the times. In the other 50% the correct combination has a poorer χ^2 with a decresing probability of being the right one with increasing χ^2 rank (see Figure 1).

Whenever the first combination is not the correct one, a not optimal mass value is entered into the spectrum, providing a *"combinatorial background"*. Our target to reduce this type of background.

The idea of the present study (see also [6] and [4]), is to recover in part the mass information contained in the combinations beyond the first χ^2 one. One could consider making use of all of them, but the mathematical and computing effort whould probably not be justified given the very low probability of the large χ^2 combinations of being the correct one (see figure 1). We chose to include the 3 best combinations in the study, as a reasonable compromise.

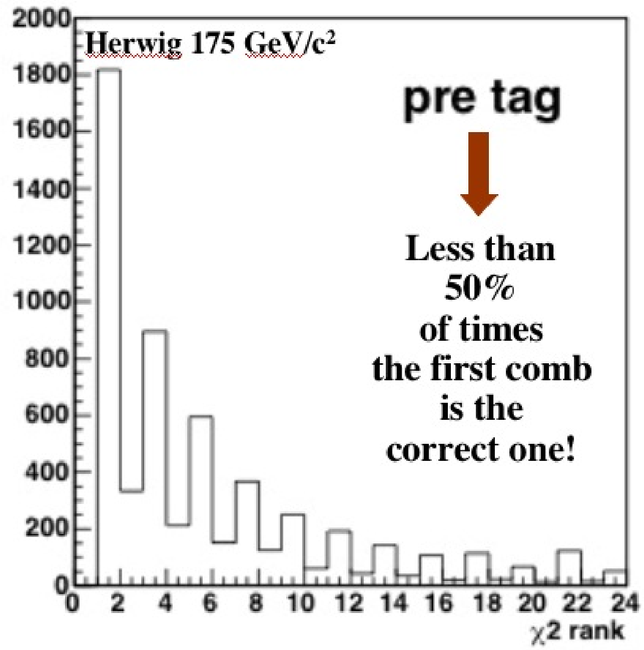


Figure 1: *The plot shows, for the Herwig MC simulation with* $M_{top} = 175$ *GeV and* $\chi^2 < 9$*, how many times the* χ^2 *rank indicated horizontally corresponds to the correct combination. The plot is related only to the Fitter, in the sense that it does not describe the efficiency in matching correctly jets and partons. After assuming this efficiency to be one (it is instead about* 54%*), we notice that bout* 50% *of times, the first reconstruction is correct. The* $(2n+2)th$ *bins are less populated than the* $(2n+1)th$ *ones because they are often discarded to avoid double counting. This happens when the 2nd degree equation for the neutrino longitudinal momentum determines one single mass value providing a multiplicity 2 solution. We reject the second solution whenever it differs less than* 100 MeV *from the first one.*

2 Montecarlo samples

We applied BLUE to a MC pretag sample of $t\bar{t}$ events with 4 or more jets, after applying a $\chi^2 < 9$ cut. The pseudodata simulate the first 760 pb^{-1} of CDF data.

2.1 Expected number of signal and BG events

We are going to estimate the number of BG and signal events in our pretag sample starting from the BG composition of the b-tagged sample. This was estimated from an integrated luminosity of 695 pb^{-1} of so-called goodsilicon events. The observed ≥ 1 tag candidates, after requiring 4 or more jets, are $N_{tot} = 468$. By applying the $\chi^2 < 9$ cut efficiency we find in this data founding a total of 446 Top candidates. We will correct *a posteriori* the estimated BG numbers by the factor 1.0935 to normalize to our 760 pb^{-1} statistics. The estimated background rates in the b-tagged sample are used for the calculation of each background contribution in the pretag sample. This is done by making use of the tag efficiency.

In order to be able to build the pseudodata mass spectrum, we need to estimate how many of the N_{tot} candidates are expected to be signals and how many BG.

$$N_{tot} = N_{t\bar{t}} + N_{BG} \tag{2}$$

Since we deal with tagged sample, we can write the total number of tagged events by distinguishing the different contributions. We divide the BGs into two categories: the *absolute backgrounds* whose expected values $N^{tag}_{i,abs}$ are predicted by specific studies and published in [5], and the *W+jet backgrounds* for which the expected number is deduced as a fraction λ_i^{fakeW} of the number of the tagged fake-W backgrounds N^{tag}_{fakeW}. $N^{tag}_{t\bar{t}}$ is the number of tagged signals. According to table 1:

$$N^{tag} = N^{tag}_{t\bar{t}} + \sum_{i=1}^{7} N^{tag}_{i,abs} + \sum_{i=1}^{6} N^{tag}_{fakeW,i} \tag{3}$$

The sum indexes are related to the BG contributions considered which are reported in table 1. We name $f = N_{t\bar{t}}/N_{tot}$ the Top fraction and we divide by N_{tot} in order to obtain an expression in terms of the efficiencies:

$$\varepsilon_{tag} = f \cdot \varepsilon_{t\bar{t}} + \sum_{i=1}^{7} \varepsilon_i^{abs} \lambda_i^{abs} + \frac{N_{fakeW}}{N_{tot}} \sum_{i=1}^{6} \varepsilon_i^{fakeW} \lambda_i^{fakeW} \tag{4}$$

where ε_i^{abs} and ε_i^{fakeW} are the tagging efficiencies of the absolute and W-like contributions, $\lambda_i^{abs} = N_i/N_{tot}$ and λ_i^{fakeW} is the i-*th* fraction of the overall tagged fake-W sample.

We built then a likelihood function describing the probability to get $f \cdot N_{tot}$ $t\bar{t}$ signals and we used MINUIT to maximize it, assuming a binomially distributed number of tagged $t\bar{t}$ events and gaussian distributed backgrounds.

The likelihood equation is minimized with respect to f, allowing the α_i parameters to vary within 1σ.

$$\begin{aligned} -\ln \mathcal{L} \;=\; & -\ln(\varepsilon_{tag}^{N_{tag}}(1-\varepsilon_{tag})^{N_{notag}}) && + \tfrac{1}{2}\left(\tfrac{\alpha_1-\varepsilon_{tag}}{\sigma_{\varepsilon_{tag}}}\right)^2 \\ & + \textstyle\sum_{i=2}^{8} \tfrac{1}{2}\left(\dfrac{\alpha_i - N^{tag}_{abs,i}}{\sigma_{N^{tag}_{abs,i}}}\right)^2 && + \textstyle\sum_{i=9}^{16} \tfrac{1}{2}\left(\dfrac{\alpha_i - \epsilon_i^{abs}}{\sigma_{\varepsilon_i^{abs}}}\right)^2 \\ & + \textstyle\sum_{i=17}^{22} \tfrac{1}{2}\left(\dfrac{\alpha_i - N^{tag}_{fakeW,i}}{\sigma_{N^{tag}_{fakeW,i}}}\right)^2 && + \textstyle\sum_{i=23}^{29} \tfrac{1}{2}\left(\dfrac{\alpha_i - \varepsilon_i^{fakeW}}{\sigma_{\varepsilon_i^{fakeW}}}\right)^2 \end{aligned} \tag{5}$$

The background processes and the relative indexes which appear in equation 5 are given in table 1. Indexes from 9 to 16 refer to the tagging efficiencies of processes having the estimated $N^{tag}_{abs,i}$ with $i = 2...8$ and inxexes from 23 to 29 refer to efficiencies of processes having the estimated λ_i^{fakeW} with $i = 17...22$.

	BG process	i
Absolute	Non-W (QCD)	2
	WW	3
	WZ	4
	ZZ	5
	$Z \to \tau\tau$	6
	single top t	7
	single top s	8
fake W	Wbb, 1B matched	17
	Wbb, 2B matched	18
	Wcc, 1C matched	19
	Wcc, 2C matched	20
	Wc	21
	$W \to u, d$	22

Table 1: *BG processes whose contribution is taken in account by maximizing the likelihood giving the ttbar signal fraction as described in the text. The fake W BSs are indicated together with the number of matched jets from b or c quarks [7].*

After normalizing to the 760 pb^{-1} pretag sample and applying a $\chi^2 < 9$ cut (which efficiency was calculated to be 92.5% from the data sample), we get the estimations given in table 2 which we use for each PE of this study. The relevant BG contaminations are also reported as fractions of the combined BG sample.

#	events	446
	$t\bar{t}$ signals	235
	BGs	211
BG	$W \to L.F.$	64.4 %
	$W \to H.F.$	14.1 %
	QCD	13.7 %
	WW/WZ	7.8 %

Table 2: Estimated number of signal and BG events in our PEs, and composition of the combined background sample. $W \to L.F.$ is the process having index 22 in table 1, $W \to H.F.$ corresponds to indexes 17,18,19,20,21.

2.2 Templates

In order to evaluate the statistical improvement given by the BLUE method applied to the 3 best reconstructed top masses, we have studied separatly the three combinations and combined their results.

To do this, we produced a mass and background templates for the first, second and the third combination. The background and mass templates generated with each combination were used to run the likelihood fit of the corresponding pseudodata sample.

The Top mass templates (Herwig) were sampled for the following 10 masses: $150, 155, 160, 165, 170, 175, 180, 185, 190, 195\ GeV$. Figures 2 and 3 show the three templates for background and for four selected Top masses.

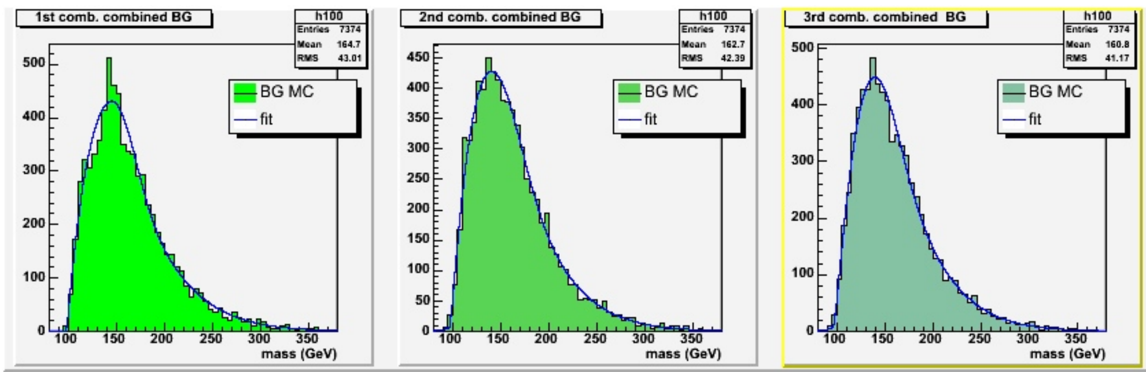


Figure 2: *The three BG (all channels added) templates. The histograms show the MC events, the fitted continous curvesare the sum of a gaussian and of the integrand of a gamma function.*

3 Quality checks

3.1 Reconstructed mass

We performed the usual quality checks on the three likelihood fits. Figure 4 shows the output masses versus the input masses. Each point was obtained by running 5000 pseudoexperiments (PEs). The slopes of the fitting lines are respectively 1.009 ± 0.008, 0.992 ± 0.006, 1.007 ± 0.008 for the first, second, third combination. In all cases the slope is well consistent with the expected value 1.0.

3.2 Pull distributions

The means and widths of the pull distributions have been generated for each mass template and are reported figure 5. For each mass we studied the reconstruction quality of the three best combinations.

The dependences of the pull means and widths on the generated Top mass were fitted to constant lines, the fitted values are reported in table 3.

To estimate the error in the pull values due to the limited number of PEs, we proceed as follows:

- We choose a reference mass template, at $M_{top} = 170\ GeV$.

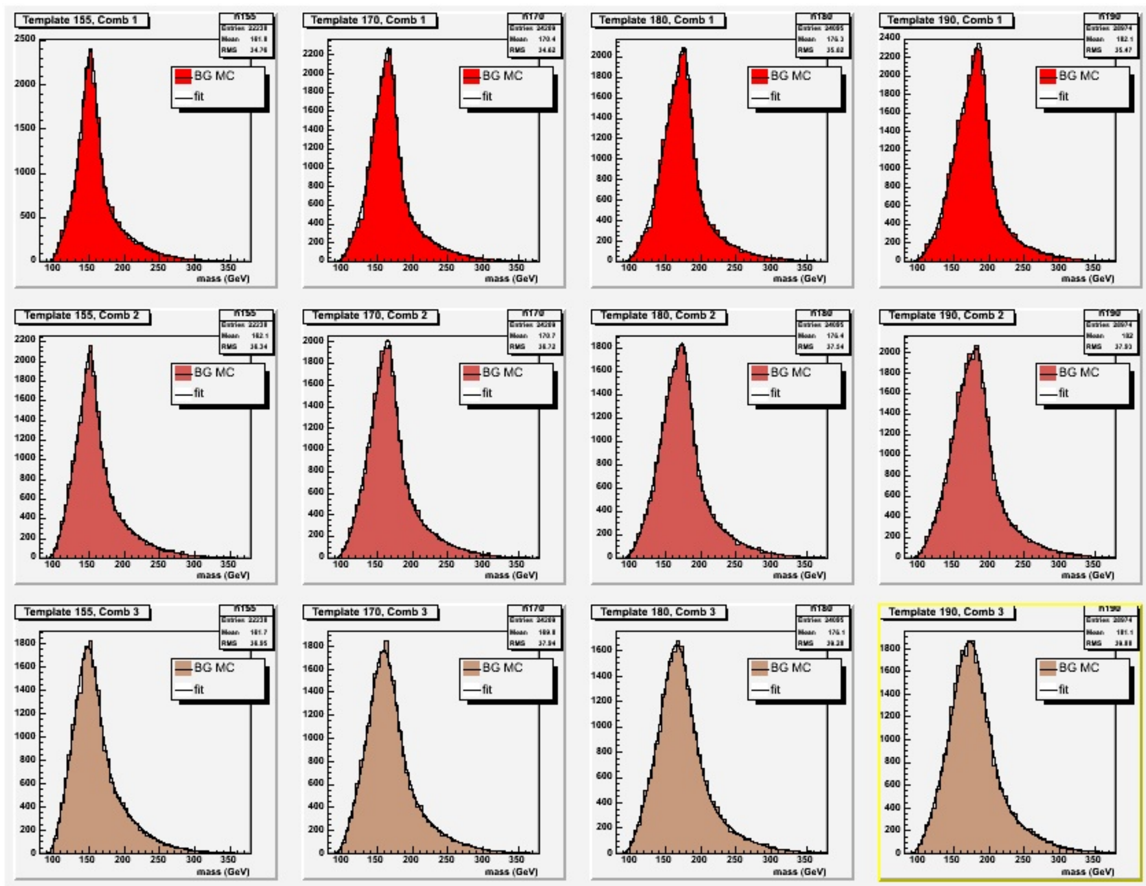


Figure 3: *Left to right: mass templates for* 155, 170, 180, 190 GeV/c^2 *Top masses and (top to bottom) first, second and third combination. As expected, the higher the combination rank is, the wider the template is. This is due to the decreasing fraction of correct combinations in the samples.*

Combination	p_0^{mean}	p_0^{width}
1	0.013 ± 0.032	1.008 ± 0.016
2	0.014 ± 0.031	0.989 ± 0.018
3	0.064 ± 0.030	0.944 ± 0.016

Table 3: *Values of the constant lines fitting the pull means and widths in their variation with the generated top mass. The means are in good agreement with expectations for combinations 1 and 2. The fits are not as good for combination 3.*

- The single bins of the 170 GeV mass are fluctuated poissonianly 500 times, getting 500 spectra. This is done for combinations 1, 2, 3.
- We analize each variation of the original spectrum using our standard procedure and generating for each of them 500 pseudoexperiments.

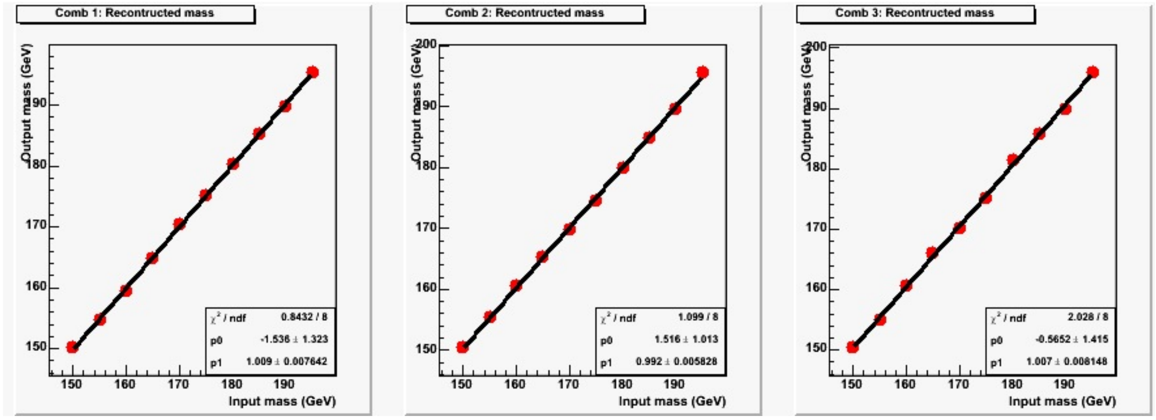


Figure 4: *Output masses versus input masses. All three slopes are consistent with the unity.*

- The results are studied for each fluctuated spectrum. For each variation and each combination, we plot the pull distribution, and fit them to a gaussian. The mean is entered into a "means" histogram and the width to a "widths" histogram.
- The "means" and "widths" histograms are fitted to gaussians giving the estimated errors on pull mean and pull width.
- For other input masses i having different number of events passing the cuts, we correct the error by the factor $\sqrt{N_{170}/N_i}$.

4 The BLUE method

The BLUE method (Best Linear Unbiased Estimate) [1] is a statistical procedure for combining different correlated measurement of the same physical quantity. The correlations are taken into account by means of the error matrix E.

In order to apply BLUE, one computes a set of parameters α_i to be used as weights to linearly combine the single measures x_i:

$$x_{combined} = \sum_i x_i \alpha_i \tag{6}$$

with the constrain:

$$\sum_i \alpha_i = 1 \tag{7}$$

The parameters vector α_i is calculated in such a way, to minimize the combined variance given by equation 8, where E_{ij} is the correlation matrix.

$$\sigma^2_{combined} = \sum_i \sum_j E_{ij} \alpha_i \alpha_j \tag{8}$$

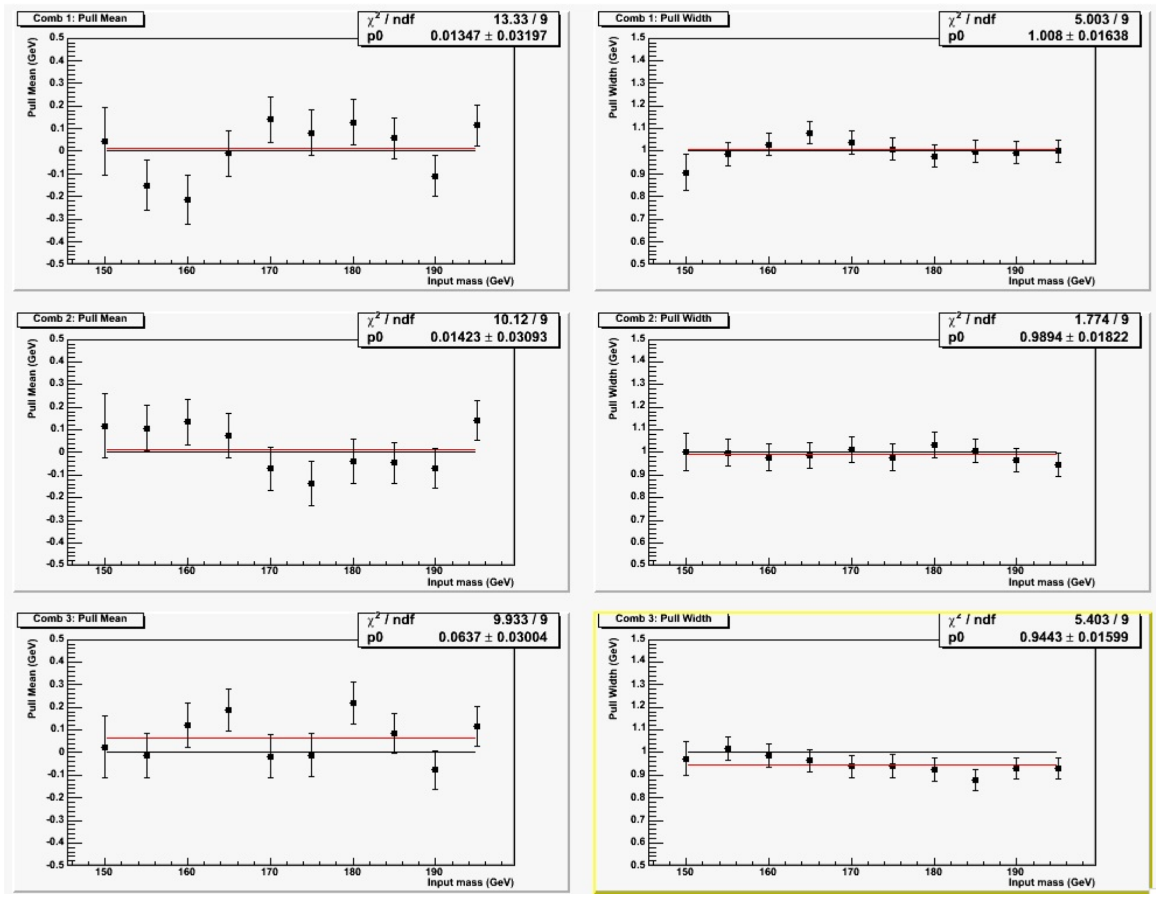


Figure 5: *The left column shows the pull distribution means and the right column the pul distribution widths. The rows correspond to the three combinations, in order up to down. The relatively large error bars are due to the limited statistics. The red horizontal lines show the constant fits.*

In the 3-dimensional case the combined variance is:

$$\sigma^2_{combined} = \begin{pmatrix} \alpha_1 & \alpha_2 & \alpha_3 \end{pmatrix} \begin{pmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{12} & \sigma_2^2 & \sigma_{23} \\ \sigma_{13} & \sigma_{23} & \sigma_3^2 \end{pmatrix} \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{pmatrix} \tag{9}$$

This method guarantees the combined variance to be not larger than the smallest variance given in input.

All error matrix elements are needed to minimize the combined variance. Since the matrix is symmetric, in the 3D case we need to calculate 6 independent matrix elements.

The 3 off-diagonal elements can be obtained as:

$$\sigma^2_{ij} = \rho_{ij}\sigma_i\sigma_j \tag{10}$$

$$\rho_{ij} = \frac{\sigma_{ij}^{PE}}{\sigma_i^{PE}\sigma_j^{PE}} \tag{11}$$

To calculate the 6 needed matrix elements, we need to run an large number of pseudoexperiments in order to study the correlations between the (three) independent (but correlated) measures we want to combine. The calculation proceeds as follows:

- from the full PE sample, we calculate the correlation factors $\rho_{12}, \rho_{13}, \rho_{23}$ according to equation 11.
- for the n-*th* pseudoexperiment and its parameter set $m_1, m_2, m_3, \sigma_1, \sigma_2, \sigma_3$ (or for *the* data set) we calculate the n-*th* covariances $\sigma_{12}, \sigma_{13}, \sigma_{23}$ obtaining the full error matrix (equation 10). A covariance is calculated as $\sigma_{ij}^N = 1/N \sum_{ij}(x_i - \bar{x})(y_j - \bar{y})$.
- we calculate the n-*th* set of $\alpha_1, \alpha_2, \alpha_3$ factors.

5 Combination of the reconstructed masses

We built each PE by extracting randomly 211 events from the BG sample and 235 events from the MC mass templates[4] and recorded the best χ^2 masses. For the second and the third χ^2 sets, we took the same events, and recorded the second and third combination masses in order to preserve the correlations.

Figure 6 shows the observed mass correlations in the pretag sample between first/second, first/third and second/third combinations in the PEs. The correlations were calculated for the MC sample relative to $M_{top} = 170\ GeV$.

As described at the end of section 4, from the correlation factors we can calculate for each PE the full α set. To check for a possible mass-dependance, we did this calculation for all the 10 masses used to evaluate the pull distributions: from 150 GeV to 195 GeV stepping by 5 GeV.

The result is shown in figure 7. On the left the correlation factors are shown. On the right, we show the α BLUE factors as a function of the generated Top mass. The α values reported are, for each mass, the mean of the gaussian fit to their distribution. As an example, we report in figure 8 the alpha factors distribution for the PEs at $M_{top} = 170\ GeV$.

We can now investigate the performances of the BLUE method on this analisys. As a first step, we show some result for the particular mass of 170 GeV, which lays in the middle of the mass range chosen and is very close to the latest top mass measurements.

Figure 9 (left side) shows how the 5000 reconstructed masses are distributed in the first, second, third combination and in the BLUE-combined case. All distributions are similar to each other, the BLUE combination being very close to the combination one.

[4]For example, each PE relative to the mass 170 GeV is built with 211 BG events (which do not depend on the input mass) and 235 events from the 170 GeV mass template.

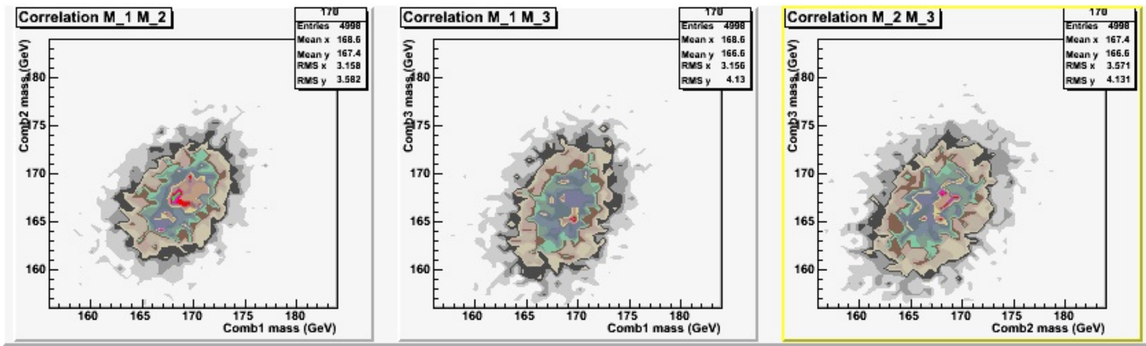


Figure 6: *Left to right: correlations between first and second, first and third, second and third combinations of the reconstructed top masses from 5K PEs at $M_{top} = 170$ GeV. Colors vary with decreasing point density from red at the center to light grey at the borders.*

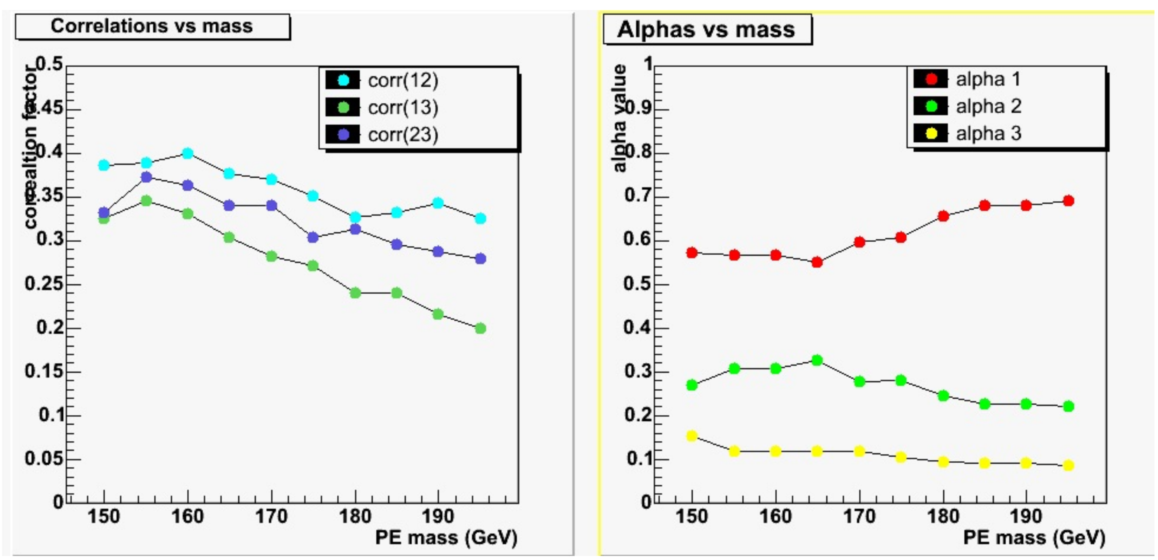


Figure 7: *Left side: correlation factors as a function of the generated top mass. Right side: α factors as from gaussian fits of their distribution for each generated top mass. An example of the α distributions for a single top mass is shown in figure 8.*

On the right side of the same figure we report the error distributions relative to the same experiments. This picture is very representative of the BLUE effectiveness: the BLUE error distribution (blue line) is sharper and peaks to lower masses with respect to the first combination (solid red). The second and third combinations are also reported.

To show the sanity of the BLUE-combined masses we report the pull distributions for the PE relative to $M_{top} = 170$ GeV in figure 10, left side. The BLUE-combined

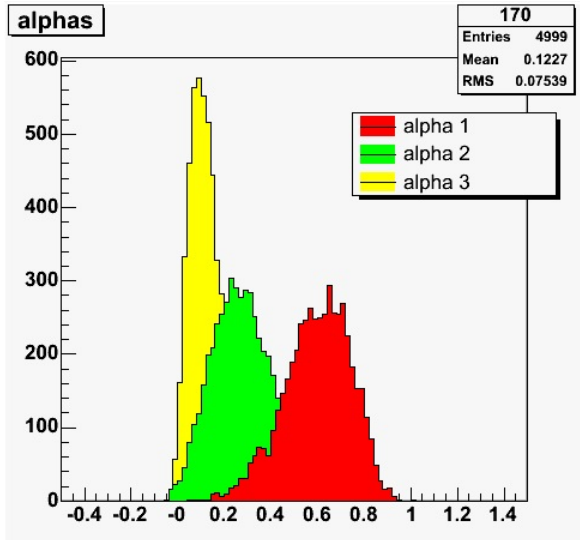


Figure 8: *Distribution of the 5000* α *factors triplets for* $M_{top} = 170$ GeV.

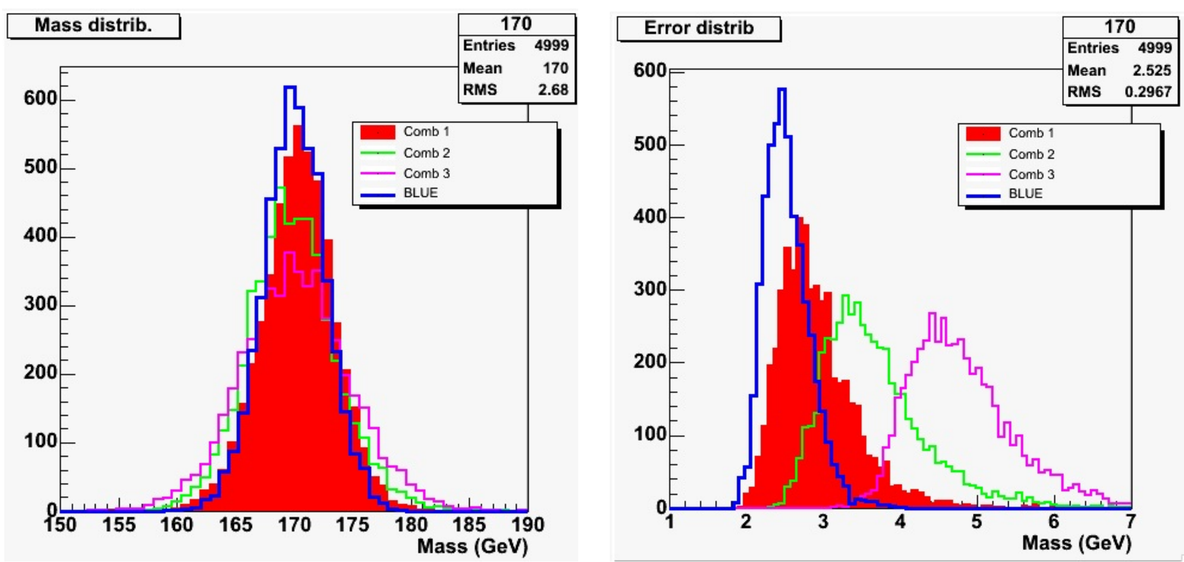


Figure 9: *Left: Reconstructed mass distribution for 5000 pseudoexperiments. The first three best* χ^2 *choices are compared together with the Blue-combined reconstructed mass. Right: same as left, but showing the error distributions. The BLUE-combined errors are smaller and their distribution is narrower than the distribution of the first combination (solid red histogram).*

pull distribution (blue histogram) is superimposed on the first combination (black histogram).

The precision with which we are able to reconstruct masses was tested on all the

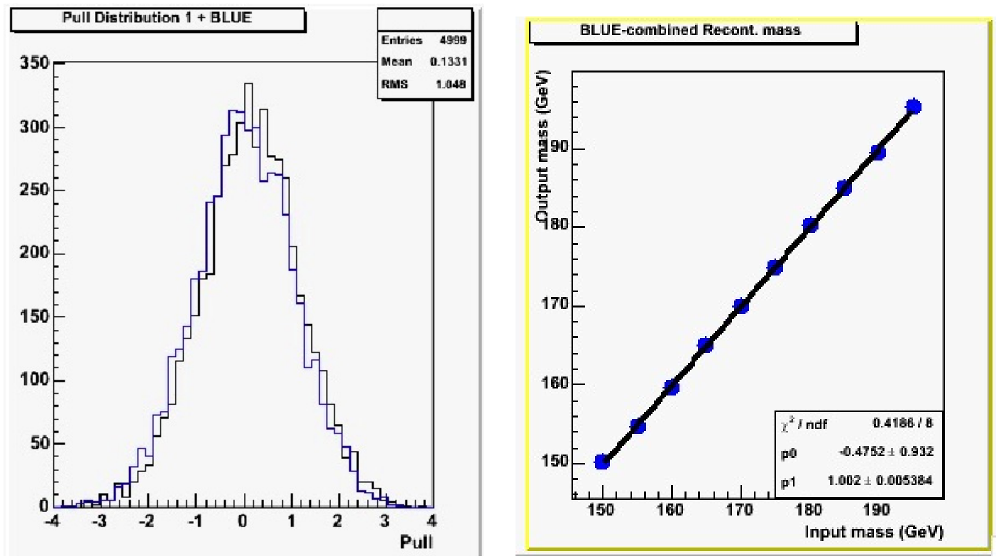


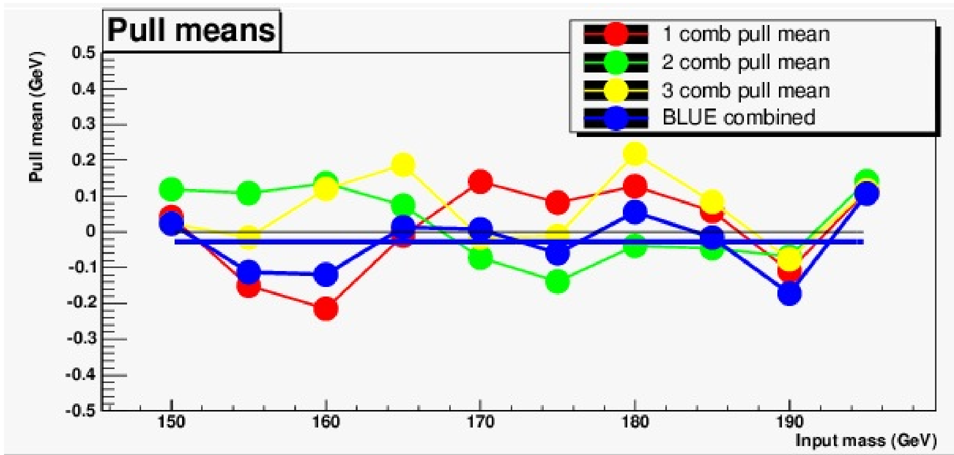
Figure 10: *Left: Pull distributions for 5000 PEs extracted from the mass template* $M = 170$ *GeV and the combined BG sample. The first combination (black line) and the BLUE-combined pull distribution (blue line) are superimposed. Right: input masses versus output masses from the reconstruction obtained with BLUE. The fitting line has a slope of* 1.002 ± 0.005.

10 input masses examined. The BLUE-reconstructed masses as a function of the input masses are shown in figure 10, right. The slope of the fitting line is reported in table 4, together with the slopes relative to the first, second, third combination (section 3.1).

Combination	Slope
1	1.009 ± 0.008
2	0.992 ± 0.006
3	1.007 ± 0.008
BLUE	1.002 ± 0.005

Table 4: *The table compares the slopes of the three best combinations and the BLUE-combined reconstructions. The BLUE slope is fully compatible with zero.*

The pull distributions means and widths of the BLUE-combined masses are reported, together with the first three combination ones, in figure 11. The blue horizontal lines are the constant fits to the BLUE pull means and width points. The values of those constants are reported in table 5 which report also the ones already given in table 3 for comparison. We notice that the fitting line to the BLUE pull means is compatible with 0 and the constant line fitting the widths is compatible with 1.0.



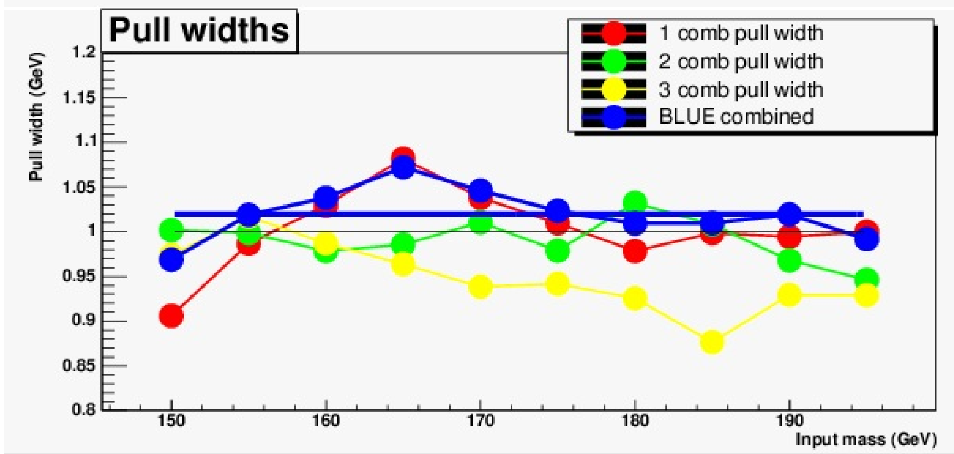


Figure 11: *Pull distribution means and widths as a function of the generated top mass for the three combinations and for the BLUE-combined measurements.*

Combination	p_0^{mean}	p_0^{width}
1	0.013 ± 0.032	1.008 ± 0.016
2	0.014 ± 0.031	0.989 ± 0.018
3	0.064 ± 0.030	0.944 ± 0.016
BLUE	-0.027 ± 0.029	1.020 ± 0.010

Table 5: *The table summarizes the values of the constant fits to the pull distributions means and widths as a function of the MC input mass.*

6 Sysematic uncertainties

To study systematics (as well as data), we need to decide which correlation factor triplet $\rho_{12}, \rho_{13}, \rho_{23}$ to use. As mentioned above, while the ρs are inferred from the PEs, the α factors come from the experiment errors set combined with the ρ.

We have seen in figure 7 (left) how the ρ_{ij} depend on the input mass. We studied the impact of a wrong ρ_{ij} assignement to a mass template. We first calculated the ρ_{ij}

triplets for the three masses $150, 170, 190\ GeV$, then we studied all the mass template by imposing the $\rho_{ij}^{150}, \rho_{ij}^{170}, \rho_{ij}^{190}$ values in the BLUE calculation. The result is reported in table 6.

M_{in} GeV	$\sigma(\rho_{150})$ GeV	$\sigma(\rho_{170})$ GeV	$\sigma(\rho_{190})$ GeV
150	2.20	2.21	2.12
155	2.30	2.31	2.23
160	2.40	2.41	2.32
165	2.54	2.55	2.46
170	2.53	2.54	2.46
175	2.57	2.58	2.50
180	2.63	2.63	2.55
185	2.62	2.62	2.56
190	2.66	2.66	2.60
195	2.71	2.70	2.64

Table 6: *The table shows the changing in the BLUE error by imposing to BLUE the ρ tripletsappropriate for $M_{top} = 150, 170, 190\ GeV$.*

The errors found are very close to each other (within less than $0.1\ GeV$) when changing the ρs. This proves that the ρ can be computed for a reference mass, and be applied to all studies.

We conclude that the systematic uncertainties can be studied by means of a single ρ triplet. We chose the triplet obtained from $M_{top} = 175\ GeV$ which is: $\rho_{12} = 0.352$, $\rho_{13} = 0.271$, $\rho_{12} = 0.303$.

7 Results

To test the BLUE performances on the top mass measurements for the prestag sample, we produced for each of the 10 generated masses reported in section 2.2, 5K PEs. Each PE has 235 $t\bar{t}$ events randomly picked up from the MC template and 211 background events randomly taken from the MC combined background sample.

For each combination (1,2,3) and for each input mass, the 5K PE were sequentially fitted and BLUE-combined as described in sections 4 and secsec:comb. We obtained for each input mass 4 distributions for the masses (3 best combinations + BLUE) and 4 distributions for their measurement errors. The mean of the Gaussian fits of those 8 distributions give for each mass four measurements. We are interested to compare the first combination (the usual analysis procedure) with the BLUE-combined one. The results are all reported in table 7 which also reports the percent improvement obtained by applying this method.

We conclude that the tests on MC samples indicate that a significant improvement can be obtained by applying BLUE. We evaluate in about 10% the improvement in statistical error that is possible to obtain by applying BLUE to the L+J top mass

Input mass (GeV/c^2)	Comb	Mass (GeV/c^2)	σ (GeV/c^2)	Improvement (%)
150	1	150.14	2.51	
	2	150.40	3.13	
	3	150.38	3.78	
	BLUE	150.09	2.20	-13
155	1	154.69	2.66	
	2	155.40	3.17	
	3	155.12	4.11	
	BLUE	154.76	2.32	-13
160	1	159.44	2.76	
	2	160.54	3.30	
	3	160.66	4.31	
	BLUE	159.74	2.41	-12
165	1	164.97	2.94	
	2	165.30	3.45	
	3	166.08	4.68	
	BLUE	165.04	2.53	-14
170	1	170.37	2.86	
	2	169.80	3.57	
	3	170.11	4.73	
	BLUE	170.02	2.51	-12
175	1	175.29	2.87	
	2	174.62	3.68	
	3	175.23	5.01	
	BLUE	174.86	2.53	-12
180	1	180.40	2.86	
	2	179.97	3.90	
	3	181.43	5.36	
	BLUE	180.17	2.56	-10
185	1	185.20	2.82	
	2	184.89	3.97	
	3	185.73	5.46	
	BLUE	185.00	2.56	-9
190	1	189.75	2.86	
	2	189.75	4.02	
	3	189.95	5.70	
	BLUE	189.57	2.60	-9
195	1	195.39	2.89	
	2	195.66	4.14	
	3	195.94	5.93	
	BLUE	195.30	2.62	-9

Table 7: *Results of measurements on pseudodata sets extracted from the mass templates and the combined background sample. The measurements relative to the three best combinations are compared with the combined BLUE measurement. The statistical improvement in the error estimation is about* 10%.

analysis. We also notice by studying the pull distribution means that the BLUE mass measurements are in very good agreement with the input MC mass, as well as better than the measurement we made by using the first combination only.

Finally, we observe that the BLUE method does not conflict with the JES technique that was recently applied to the Top mass measurement. The two techniques applied together could lead to additional progress.

References

[1] L. Lyons, D. Gibaut; NIMA A270 1998 110-117.

[2] H. Bachacou et al, CDF Internal Note 7562.

[3] H. Bachacou et al, CDF Internal Note 7535.

[4] G. Bellettini et al, CDF Internal Note 6770.

[5] S. Budd et al, CDF Internal Note 8037.

[6] M. Giunta et al, CDF Internal Note 8177.

[7] PRD 71, 052003 (2005).